#00-03 (May-Jun 00)

# EUROGRAM

## EUROPEAN OFFICE OF AEROSPACE RESEARCH AND DEVELOPMENT

## CC HIGHLIGHTS

EOARD welcomes Lt Col Dave Burns and Dr. Chris Reuter, who both joined us in March. Dave comes from the Sensors directorate at Wright-Patterson AFB in Dayton, Ohio, where he was the deputy division chief for the Radio Frequency (RF) Sensor Technology Division (AFRL/SNR), with technical focus in radar, electronic warfare, signal processing, and apertures. Dave graduated from the Air Force Academy in 1983, completed an M.S. in Electromagnetics at the University of Dayton, and a Ph.D. in Micro-Electro-Mechanical Systems (MEMS) from the Air Force Institute of Technology in 1998. Dave also completed the Advanced Program Management Course at the Defense Systems Management College in Fort Belvoir, Virginia, in 1999. Most of his past assignments have been acquisition-related, including positions in the F-22 electronic warfare, B-2 mission planning, Minuteman III capsule command & control system, and advanced reconnaissance systems (SAF/AQL) program offices. His duty assignments include two tours at Wright-Patterson, and one each at Hanscom AFB MA, the Pentagon, and now London. Dave’s interests include radar, RF propagation, RF components, signal processing, antennas, and MEMS. He is married and has four children. David.Burns@London.af.mil

Chris Reuter joins us from the Information Directorate at Rome, New York, where he was a Research Engineer for the Advanced Computing Architectures group. Chris has degrees in Electrical and Biomedical Engineering from Marquette University (B.S. 1986, M.S. 1988), and a Ph.D. in Electrical and Biomedical Engineering from Northwestern University in 1993. A native of Wisconsin, Chris followed his Ph.D. with a post-doc at Northwestern before joining the team at Rome. Chris’ interests include information technology, signal processing, and computational electromagnetics. He is married and has two children. Chris.Reuter@london.af.mil

*And now for the headlines:*

- Feature article: Atmospheric Modeling, Characterization and Real-Time Image Restoration
- Dutch/German Fiber Metal Laminate Structures Bear Fruit with Airbus A3XX Launch
- EOARD and Johns Hopkins View Advanced Russian Aerospace Technologies
- AFRL/VS and EOARD Visit Cryocooler UK Technologies
- DLR-Stuttgart Demonstrates Laser Propulsion

Gerald T. O’Connor, Colonel, USAF
Commander, EOARD

## Contents



# Feature Article

## Atmospheric Modeling, Characterization and Real-Time Image Restoration

Dr. Norman Kopeika (kopeika@ee.bgu.ac.il) of Ben Gurion University of the Negev, Be'er, Israel has been working in the areas of atmospheric modeling, characterization, and image restoration for over ten years. He has led major study efforts that could have potential impact on AFRL and ABL programs. For example, the atmospheric propagation community usually overlooks the effect of aerosols and attributes all of the observed effects to turbulence. By contrast, the remote sensing community overlooks the importance of turbulence and attribute the effects they see to aerosols. Because of the importance of using the best possible model for atmospheric propagation and remote sensing, I requested brief summaries of his work. My hope is that those working in these two related fields take a new look at significant atmospheric processes focussing on areas that might have been previously overlooked. Dr. Kopeika's results might help to begin to adjust the models.

**"**ATMOSPHERIC MODELING

While atmospheric blur is often attributed in the propagation community to turbulence, it has been well known in the remote sensing community since the late seventies that essentially ALL atmospheric blur derives from small angle (milliradians and tens to hundreds of microradians) forward scatter of light by aerosols. This is usually referred to as the "adjacency effect" since such small angle scatter of light by aerosols causes photons to be imaged in pixels adjacent to where they should have been imaged. The larger the sizes and concentrations of the aerosols, the more the light scatter is concentrated in the forward direction as a result of diffraction by such particles. A summary of adjacency effect literature around the world is found in ref. [1]. We have found that while dynamic atmospheric properties such as scintillations and image dancing or angle of arrival fluctuations are caused primarily by turbulence, a significant amount of static blur derives from aerosols over horizontal paths too. While turbulence often dominates atmospheric blur close to the ground, at elevations of several meters and more above the ground aerosol blur often becomes more dominant, depending on weather and atmospheric optical depth. Over the sea and the desert, aerosol blur dominates even closer to the surface.

Point spread function (psf) modeling characterizes image blur. However, the same approach can be used to characterize the widening of laser beams caused by the atmosphere, since for long paths a laser aperture can be viewed as a point source. However, a distinction must be made between laser beam widening and image blur. Because the aerosol scattering pattern is very wide, the imaging instrumentation usually truncates the psf actually recorded in the image. Much of this modeling is summarized in ref. [2], with some data shown in ref. [1]. On the other hand, laser beam widening depends on atmospheric properties alone.

Vertical profiles of aerosol loading and turbulence strength ($Cn^2$) are qualitatively rather similar. Both decrease greatly at the boundary layer from their values near the surface. Both continue to decrease as elevation increases, until elevations on the order of 10-25 km where both increase [2,3]. In the case of aerosols, such increase in the stratosphere is attributed to meteoric and possible volcanic dust. We suspect the increase in $Cn^2$ at such altitudes may involve such aerosols. Indeed, we have found that near the surface increases in aerosol loading correlate well with increases in $Cn^2$ [2]. This is attributed to atmospheric warming well known in the remote sensing community to arise from absorption of infrared radiation by the aerosols. Since the vertical profiles of both aerosol loading and turbulence strength are somewhat similar, and since aerosol blur is attributed in the remote sensing community to be the only source of atmospheric blur when imaging downward, there is strong reason to suspect that the inability of adaptive optics to correct for all atmospheric blur derives from the fact that adaptive optics do not correct for aerosol blur[4]. In other words, the atmosphere is not a one way medium. What blurs in a downward path should be taken into account too when viewing upward.

The approach we have developed is a broad system engineering approach described in ref. [2] and the very many references cited there. It includes turbulence, aerosols, atmospheric absorption, and atmospheric path radiance. Such absorption is a very important part of aerosol modulation transfer function (mtf), especially in the infrared.

ATMOSPHERIC CHARACTERIZATION

One way of characterizing aerosol and turbulence blur over a given atmospheric path is to illuminate a target, such as the surface, with a laser beam, and to image that laser beam spot. The size of that laser beam spot yields the overall psf. Fourier transformation yields overall mtf. Division by instrumentation mtf yields overall atmospheric mtf. The image dancing (angle of arrival fluctuations) yields path-averaged $Cn^2$ over that line of sight, from which turbulence mtf can be calculated [2]. Both the psf and $Cn^2$ calculations are simultaneous and over the same pixels. Regarding psf, a large number of very short exposures are averaged without the tilt displacement to determine average overall psf. Regarding $Cn^2$, the location of each laser spot is used to calculate variance in angle of arrival fluctuations, from which $Cn^2$ is determined [2,5]. Division of overall atmospheric mtf by turbulence mtf then yields aerosol mtf. Each is treated differently in atmospheric Wiener filter image restoration so as to yield an image corrected for aerosol blur, turbulence blur, and atmospheric path radiance. The correction is very close to being total, even over long atmospheric paths near the ground [2] which are much more heavily blurred than vertical paths.

As regards laser beam widening, an analysis of vertical profiles of $Cn^2$ and aerosol loading in the literature indicates that in horizontal propagation of laser beams at various elevations, the widening caused by aerosols is not only very significant but is typically even greater than that caused by turbulence [3]. The problem is that such measurements were not in the same locations and were not simultaneous. We are currently measuring vertical profiles of both in the same location almost simultaneously using lidar. As such they are unique. We hope to continue them during the various seasons of the year and to use them to try to predict the broadening by each process individually and together according to season and weather for both daytime and nightime. We are looking for support for this. An important application is to predict which ELEVATION would yield minimum OVERALL laser beam widening according to season, weather, time of day, etc.

IMAGE RESTORATION

We have developed several unique types of image restoration. The atmospheric Wiener filter [2,6] is mentioned above. It enhances the image at selected high frequencies where instrumentation noise and turbulence jitter are least. We have also developed a method for doing this electronically even without a computer, and a REAL TIME prototype has been built [7]. The restoration time is two frames. We have ideas to reduce this time to that of a single frame. If a computer is to be used anyway for additional purposes, this technique can be regarded as preprocessing. If an improved image is input to the computer, then the computer has less work to do and it can then do it faster.

We have also carried out a great deal of research in restoring images from motion and vibration blur. This is important when imaging from tanks, planes, ships, etc. and especially from helicopters. Even if the blur size is an order of magnitude larger than the size of the detail that is blurred, complete recovery is obtained [2,8]. While this is not yet real time, we are presently working on electronic filtering techniques similar to [7] to be used to restore images from motion and vibration blur in real time. Since stabilization equipment is heavy, massive, and quite expensive, these techniques can be used to improve cost-effectiveness quite considerably.

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# PROGRAM MANAGER REPORTS

*Lt. Col. Rob Fredell*
*Technical Director*

**Conference: CEAS Crashworthiness of Airframes conference, Capua, Italy, 13-15 Feb 2000.** This conference provided a review of the state of the art in crashworthy and energy-absorbing structural design for rotary and fixed-wing aircraft. Primary emphasis was on numerical modeling methods. Of particular interest was the growing use of metal foams and crush tubes as energy-absorbing structural elements. Dr. Michel van Tooren of TU Delft, the Netherlands, presented an interesting concept for a low-cost, crashworthy aircraft seat using viscoelastic foam as the seat cushion.

The conference included a tour of CIRA, the Italian Center for Aerospace Research, a new consortium formed by the Italian government and key Italian aerospace firms. 200 researchers work there in basic and applied research into non-destructive evaluation, composite materials testing, evaluation of crashworthiness of aerostructures, and aerodynamics. Two facilities are considered world class: the 7 MW Plasma Wind Tunnel, nearing operational status, and the 10-ton dynamic crash test facility. The latter consists of a high-speed movable crane mounted on a rigid track. The device allows controlled impact of aircraft into either water, concrete or dirt surfaces at angles of incidence adjustable from vertical to near-horizontal.

**Meeting: Planning for Bio/Structural Mechanics of Crash conference, Cranfield, UK, 9 March 2000.** Tremendous advances have been achieved during the last fifty years in the understanding of human tolerance to rapidly applied loads. This has enabled engineers to design satisfactory "crashworthy" vehicles and aircraft. However, one of the challenges facing the science of impact biomechanics at the start of the new millennium will be to develop a better understanding of the injury mechanisms behind severe brain injuries, and injuries to the head and neck. Utilizing current techniques, including MRI and mathematical modelling of the brain, will assist in the re-evaluation and improvement of the existing head injury criteria. Impairing injuries as a consequence of the loading of the spine are still common and need to be further studied.

This workshop, planned for 16-18 October 2000 at Cranfield, will bring together some of the leading researchers in the world in order to establish the current level of knowledge in the biomechanics of the head and neck to set up guidelines for needed areas of research in the next millennium. The objective will be to advance the science of impact biomechanics, thereby making it possible to mitigate fatal as well as severe head and neck injuries in air and other transportation crashes. Areas of interest will be:

- Head, brain and neck injury mechanisms
- Current diagnostic techniques of head, brain and neck injuries
- Treatment and rehabilitation of injuries
- Injury tolerance levels
- Safety and crashworthiness
- Analytical and mathematical modeling of head, brain and neck complex
- Epidemiology, histology and pathology related to injuries
- Effects of head-mounted mass (helmets)

The workshop will be limited to an invited group of 60 delegates and will include a series of keynote addresses and technical presentations by prominent workers in the field. The audience will comprise experts from both medical and biomechanics disciplines from military, commercial and academic backgrounds. For more information contact Dr. Sampath of the Army Research Lab, European Research Office.

**Site Visit: Structural Materials Laboratory, Technical University of Delft, The Netherlands, 28 – 29 March 2000.** Professor Boud Vogelesang, host and POC, provided an overview of the substantial progress made by his group and Structural Laminates Industries in the development of the fatigue-resistant aluminum/ glass fiber/epoxy family of laminates known as GLARE. Working closely with Airbus Industrie, Delft and SLI have taken this high-strength material from concept to large-scale realistic stiffened fuselage structures for very large transport aircraft. The GLARE concept involves bonded stiffeners and splices that greatly reduce the number of parts required for assembly of a transport fuselage while retaining and improving upon the damage tolerance inherent in a built-up (vs. monolithic machined) structure. The concept reduces the cost of assembly to offset the seven times more expensive GLARE and make it competitive with the final assembly cost of a traditional riveted aluminum fuselage. Further benefits of the GLARE fuselage include:

- 20% lighter than aluminum structures,
- greatly improved fatigue and corrosion resistance that requires fewer inspections,
- excellent impact performance, and
- burn-through resistance approaching titanium

Prof. Adriaan Beukers set up a series of meetings with the composites group at the Center for Lightweight Structures (www.tno.nl/instit.indus/CLS.html) at the Faculty of Aerospace Engineering. Of particular note are some major composites design/development projects the Delft team has led to successful technology transition, including:

- the Extra 400, a pressurized all-composite high-performance single-engine aircraft developed and prototyped at Delft for Extra Aircraft GmbH of Germany. The structural frames are external to the fuselage skins (to better resist peel forces generated by internal pressurization).
- the Contest, a 55-ft-long sailing yacht successfully designed and prototyped using vacuum-assisted resin transfer molding (RTM). This very large single-shot (1,200 liters of epoxy) production of a seaworthy hull was transitioned to Dutch industry after the developers validated several computer codes for predicting the flow in the open mold. A second injection cycle is used for manufacturing the ribs.
- an 86-foot-long aeroelastically tailored carbon/glass/epoxy wind turbine rotor blade produced by vacuum-assisted RTM.
- all-composite isotensoid LPG containers that safely contain high-pressure fuel at 40% of the weight and less cost than conventional steel tanks

The Center for Lightweight Structures staff has agreed to give a five-day short course under the Window on Science program at the USAF Academy in the summer of 2001 to demonstrate their “holistic” approach to composite design, analysis, and manufacturing. The course will include hands-on training in the Delft-developed software packages ‘Kolibri’ (composite design and analysis), ‘Drape,” (mold design and fabric placement), and ‘RTM-worx’ (resin transfer molding simulation) and in the actual production of small RTM structural components. For further details contact Lt Col Jim Greer at the Air Force Academy (jim.greer@usafa.af.mil).

**Site Visit: Airbus Industrie, Hamburg, Germany, 6 April 2000.** Dr. John Lincoln, ASC/ENF, the Technical Advisor to Aeronautical Systems Center for Aircraft Structural Integrity, also attended this informal review of Airbus’ revolutionary approach to fuselage structures on the A3XX, a 555-seat aircraft being developed by Airbus to compete with the 747.

The A3XX fuselage represents a radical departure from conventional mechanically-fastened aluminum transport fuselages. The upper half of the A3XX has been baselined as an adhesively bonded GLARE composite structure, while the lower half is anticipated to be primarily welded 6000-series aluminum alloys. This combination is expected to result in a substantially lighter structure with comparable production costs and lower operating and maintenance costs. Further, the outer wing is likely to be a carbon fiber composite structure, another first for a large transport aircraft in series production.

In related news, Dubai-based Emirates Airlines announced on 1 May 2000 a $2.5 billion launch order for five of the new aircraft. The airline has the option to increase its order to 10 aircraft, which may include two freighter models. The first five aircraft are due in 2005 and 2006.

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*Dr. Charbel Raffoul*
*Aeronautics*

Representatives from AFOSR, AFRL, The Johns Hopkins University, Applied Physics Laboratory (JHU/APL), and EOARD traveled to Moscow to visit Russian institutes under contracts with EOARD for advanced aerospace technologies investigated under an activity referred to as the Russian Initiative.

**Meeting: Moscow Technical Company (MTC), Moscow, Russia.** Drs. Leonov and Klimov have established laboratories at the High Temperature Institute of the Russian Academy of Science (IVTAN).

Dr. Klimov showed results from recent plasma enhanced fuel injector experiments where enhanced penetration of the injected fuel was observed for both counterflow and crossflow configurations. A video was also shown where a “high-energy plasmoid” was discharged into a tube of liquid nitrogen. The glowing plasmoid was observed to exist for approximately 10 seconds before it collapsed. Dr. Klimov stated that plasmoids with lifetimes of 10-15 minutes had been generated. During one of the experiments, he was manually probing the plasmoid and it discharged through his body knocking him off of his feet. He stated that this “experiment” shows that the plasmoids are highly charged structures.

**Site Visit: Moscow State University (MSU), Moscow, Russia**. The group visited MSU to review the progress under the contract “Development of a Physical Background for the Application of Plasma Jets, Transversal Discharges, and Microwave Radiant Ion for Fuel Ignition in a Ramjet” and to discuss potential future collaborations. Academician Alexandrov, Chairman of the Radiophysics and Electronics Department in the Faculty of Physics, gave a short description of the efforts of his department in experimental and theoretical aspects of discharges. MSU has significant experience dealing with the interaction of radiation with solid surfaces, plasma sputtering, thin film deposition, ion-beam ablation, e-beam ablation, laser ablation, chemical vapor deposition, etc. The faculty has been active in investigating carbon films using ion stimulation methods, and has successfully deposited carbon, diamond, graphite, or carbine (a linear chain of carbon atoms, with the best biocompatibility for medical applications) onto surfaces in multiple layers such that the material properties can be tuned. Various plasma surface treatment techniques have been investigated for operations at atmospheric pressure. The faculty participates in a scientific and education center for micro- and nano-electronics jointly with several Russian Academy of Science Centers.

In plasma aerodynamics, Academician Alexandrov highlighted significant uncertainties in electric discharges in flowing electro-negative gases (e.g. air). These include:

- breakdown characteristics,
- formation of the discharge,
- stability of the discharges, and
- steady-state characteristics.

The MSU laboratories demonstrated experiments on both transversal and microwave discharges in supersonic flows. The test set-up consisted of a small axisymmetric nozzle that discharged flow from atmospheric conditions into a vacuum test chamber. Various types of discharges were generated in the supersonic flow produced by the nozzle. Preliminary investigations have focused on discharges into air at Mach 2 conditions. The transversal discharges have been investigated for a range of pulse widths and duty cycles. Results have shown that the discharges contain significant high frequency noise for all but the shortest pulse width discharges. The source of the noise is not known. The characteristics of the discharges have been measured using spectroscopic and electric probe measurement techniques. The length of the discharge has been shown to be a strong function of pulse duration, current, and Mach number.

Discharges were also demonstrated using a stand alone microwave discharge in the supersonic flow. The microwaves are produced using a 1 MW pulse magnetron that operates at 2.4 cm wavelength with variable pulse width between 1 and 500 μs. The microwave discharges were undercritical with small copper electrodes serving as the initiators.

The final series of plasma generators being investigated are referred to as plasmadynamic injectors. In these generators, a small amount of material is consumed in the formation and operation of a plasma jet. Capillary injectors have been investigated using an erosive organic material, but significant erosion of the walls of the generator was observed after 5-6 discharges. A second type of plasmadynamic generator consisted of a metallic tube with a co-axial central metal rod serving as the electrodes. Between the two electrodes, an erosive material (either plastic or wax) was placed. During a discharge, approximately 10,000 Amp flow for a pulse duration of approximately 1-70 μs. With the large current flowing, a significant self-induced magnetic field is generated resulting is large Lorentz forces serving to accelerate the plasma out of the injector. Spectrographic measurements of the discharge show evidence of temperatures up to 20,000K within the discharge. It was stated that an injector operating at 8000 J/pulse with 70-μs pulse duration had operated successfully for a thousand shots. Because of the high injection velocities, the jet demonstrates significant penetration through crossflows. MSU personnel estimate that penetrations up to 30 cm could be realized at conditions expected in a scramjet engine. They feel an igniter/injector and power supply would weigh approximately 5 kg.

The tour also included the MSU free-electron laser, and a small laboratory where a freestanding discharge was generated at atmospheric conditions using a pulsed-periodic waveform. The discharge was approximately 1 inch in length and unsteady with the formation of numerous streamers. The power input into the discharge was stated to be 100 W. This type of discharge is being investigated for application to surface treatment prior to painting, or chemical processing.

**Site Visit: Central Aerohydrodynamic Institute (TsAGI), Moscow, Russia.** TsAGI is one institute of the so-called five sisters: Gromov Flight Research Center, the Central Institute for Aviation Motors (CIAM), the Institute for Aviation Materials (VIAM), the Institute for Aviation Systems (GOSNIIAS) and TsAGI. TsAGI currently has 5500 staff of which half are engineers. Additional details can be found at www.tsagi.rssi.ru

TsAGI maintains an enormous wind tunnel capability: T-117 Hypersonic Wind Tunnel, T-109 Large Supersonic Wind Tunnel, T-101 and T-104 Large Subsonic Wind Tunnels, T-128 Transonic Wind Tunnel and the full-scale fatigue test facility.

- *The T-117 hypersonic wind tunnel* is an arc-heated blowdown facility with nozzles for Mach 10, 12, 14, 16, 18 and 20 and Reynolds numbers simulation capability between 150 and $10^6$. Total temperatures between 1000 and 3000K and pressures between 40 and 200 atmospheres can be produced. The facility also contained a unique dual-sting system for conducting hypersonic separation tests.
- *The T-109 supersonic wind tunnel* operates at pressures up to 6 atmospheres in the test section. A variable geometry nozzle is used to provide Mach numbers between 0.5 and 4.0 and Reynolds numbers on the order of $50x10^6$ for a one-meter model; a large acoustic field generator is capable of producing up to 130 dB. The facility also has the capability to produce a hot-engine simulation during testing.
- *The T-101 full-scale aircraft test facility* is 24 m wide and 14 m high and has a maximum velocity of 50 m/s. Complete aircraft can be tested with the engines operating. The aerodynamics for the SU-27 cobra maneuver were developed in this facility.
- *The T-104 facility*, with a 7-m diameter circular cross-section, is used for testing complete propulsion systems.

Dr. Korontsvit presented results from the EOARD contract "Experimental Investigation of Supersonic Combustion of Liquid Hydrocarbon Fuel Using Barbotage in the Aeroramp Configuration at M = 2.5." In this project, direct-connect combustion experiments were conducted using Mach 2.5 inflow conditions with a total temperature of 1700 K and total pressures between 1.7 and 2.5 MPa. Multiple injector configurations were tested using liquid kerosene aerated with either hydrogen or air. The aeroramps showed no signs of a local separation region, but they demonstrated low efficiency (due to low penetration) compared to tests conducted with microtube injectors.

Dr. Kogan recommended developing a coordinated US/Russian program in plasma aerodynamics to avoid duplication. He contends most plasma effects can be explained by accounting for the heat release of the discharge, but that increases in aerodynamic efficiency are difficult to achieve. The heating can occur from either vibrational relaxation of excited states or ion acceleration. He has not been able to show any increase in lift-to-drag ratio by heat addition using a Navier-Stokes code, and believes that further study is warranted and an optimum location for heat addition may exist for specific geometry. He also believes the effects of plasma on the stability of boundary layers or stability of shock waves are of great interest. Interesting patterns of electricity flow across shock fronts have been found. Low discharge energies could be useful when addressing stability issues.

**Site Visit: Central Institute of Aviation Motors (CIAM), Moscow, Russia.** The Institute Director, Dr. V. Skibin, gave a short introduction to CIAM and its main lines of current research, refocusing its efforts along lines of work where market interest exists with a renewed emphasis on cost. CIAM is to be integrated soon under a new Russian Aviation/Space Agency.

CIAM is investing in developing Computational Fluid Dynamics (CFD) codes for compressors and turbines including modeling of unsteady turbulent flows for 4-dimensional calculations. Multidisciplinary models coupling aerodynamics and model strength are being developed to end the decoupled aerodynamic/strength design cycle. Other interests include:

- development of an all-electric engine,
- generation of ionized particles at the exhaust of engines,
- magnetohydrodynamic (MHD) engines high enthalpy flows interacting with magnetic fields,
- pulse detonation energy engines, and

- ground-based gas turbine engines for power production.

CIAM is proceeding with their activities associated with the IGLA engine demonstrator for a hypersonic flight test program. The objective of this flight test is to demonstrate integrated airframe-propulsion performance at speeds up to Mach 14. Obviously, such a program will be expensive; CIAM is actively seeking international partners. A full-scale mockup of the flight vehicle was displayed at the Zhukovsky Air Show during the first week of September '99.

Dr. Roudakov provided a short update of CIAM's flight test capabilities including the capabilities of the Kholod vehicle used to test an axisymmetric scramjet engine at speeds up to Mach 6.5, and the IGLA flight test vehicle designed for testing at high hypersonic Mach numbers. Results from the Kholod tests were compared to those obtained in ground facilities using vitiated heaters. This vehicle could potentially be tested with any fuel possibly using an endothermic-fuel heat exchanger. Scramjet duration of approximately 10 seconds would be expected using relatively simple uncooled engine hardware. This is a special program under the aviation-space agency to determine the maximum Mach number at which a scramjet can be expected to operate.

Dr. Kopchenov discussed the advantages of adding a MHD system to the engine. Using inviscid calculations, he was able to show some degree of flow control and energy extraction. He identified the main technical problems as the generation of adequate conductivity, viscosity and flow inefficiencies. In his preliminary calculations, he was unable to show a system benefit to using the MHD system, but he stated that MHD control might still be useful in situations where mechanical control is difficult. Dr. Kopchenov also said MHD interaction in the combustor might provide a means of obtaining better combustion properties at high Mach number.

Dr. Shikman summarized activities in endothermic fuels for scramjet operation, investigating both direct-connect and free-jet testing as well as the burning of a two-phase fuel that results from partial decomposition in a subsonic combustor.

Dr. Yanovskiy concluded the presentation with a short status review of endothermic fuel reactor development. The reactor fabrication had been completed and is undergoing initial testing under the terms of the Johns Hopkins University contract. The reactor has a modular design allowing for easy repair or operation and incorporates adiabatic zones that allow for a higher degree of fuel conversion at the same temperature.

The C-16 test complex conducts research on solid and liquid fueled ramjets, scramjets and liquid-fueled rockets. Liquid engines up to 12 tons of thrust can be tested. Scramjets can be tested at conditions up to Mach 7 with supply temperatures up to 2100K and supply pressures up to 130 atmospheres. The facility contains both a 5 MW electrical resistance heater and methane or hydrogen vitiated heaters.

**Site Visit: Central Institute of Machine Building (TsNIIMASH), Moscow, Russia.** Dr. Nicolai Anfimov, the first Deputy Director of TsNIIMASH reaffirmed interest in plasma effects in aerodynamics and scramjet operation. He stated that the high Mach number pulse facility was operating every day in cooperative work with CIAM.

Dr. Vitaly Kislykh provided an overview of the high Mach pulse facility, which operates at pressures up to 3000 atmospheres, supply temperatures of 4000K and Mach numbers above 10. All Russian hypersonic vehicles were tested in the facilities and testing of the IGLA vehicle was underway. Dr. Semenov of CIAM was on-site for testing of the IGLA configuration.

TsNIIMASH also operates the largest hypersonic wind tunnel in Europe. The facility has a 12.5-m diameter by 6-m long test section with nozzles for producing Mach 2, 3, 4, 6, 8, and 10. Reynolds numbers between $10^5$ and $10^8$ can be produced, while an electric heater is capable of providing temperatures up to 1100K, drawing up to 200 MW. The facility also uses an optical flow visualization system but showed little evidence of recent activity.

The middle-size transonic facility has a test section of 0.6x0.6-m and was described as "very busy." It was in this facility that the TsNIIMASH plasmadynamic wind tunnel tests were conducted using a plasmatron to inject plasma at approximately 6000K in the forward direction from the nose of a model, *producing a 50% reduction in aerodynamic drag*. When tests were conducted using a solid-fueled gas generator that operated with an injectant temperature of approximately 2000K, the drag dropped by approximately one-third. Dr. Krasilnikov used these results to conclude that the main factor was the thermal mass addition of the plasmatron, offering a good means to inject a small amount of gas with a very high temperature and therefore significantly affect drag.

**Site Visit: Von Karman Institute for Fluid Dynamics, Brussels, Belgium.** The U.S. Air Force engagement with the von Karman Institute (VKI) spans about 45 years. In 1955, Theodore von Karman, the first USAF Chief Scientist, and the NATO Advisory for Aeronautical Research and Development proposed the establishment of an institution devoted to training and research in aerodynamics open to young engineers and scientists of the NATO nations. The Institute was established in October 1956 at Rhode-Saint-Genese, Belgium, in the buildings which formed what then was the aeronautical laboratory of the Civil Aviation Authority of the Belgian Ministry of communications. VKI is incorporated under Belgian law as a non-profit international scientific association. Dr. von Karman acted as the Institute's Chairman until his death in 1963, when the name was changed in memory of its founder.

VKI has become a well established and widely known Center of Excellence in Fluid Dynamics in which "training in research through research" is the guiding rule. VKI offers a number of programs, including a Lecture Series, Diploma Course, Research, Consulting, and an Educational Program.

- *Lecture Series:* VKI now offers ten to twelve courses attended by 400 persons annually from Europe and North America. The series are open to outsiders for a fee but free to VKI students. The aim of each 1 week lecture series is to provide in-depth presentations on topics related to fluid dynamics with particular emphasis on experimental aerodynamics. The lecturers are internationally recognized experts and the excellence of this program has done much to promote the Institute.
  *How to Apply:* Applications for admission to VKI lecture series are made to: Lecture Series Secretary – von Karman Institute for Fluid Dynamics – 72 Chaussee de Waterloo – B-1640 Rhode-Saint-Genese.
- *Diploma Course:* This nine-month program consistsof a series of lectures in theoretical and experimental fluid dynamics followed by specialization in one of:
  - Aeronautics/Aerospace
  - Environmental and Applied Fluid Dynamics
  - Turbomachinery

  The individual research project remains the cornerstone of the Diploma Course (nearly two-thirds of the academic year is devoted to it). Qualified candidates are eligible for fellowships to cover the cost of the nine-month Diploma Course. Qualifications include a Master's degree in engineering, or a Bachelor's degree with equivalent work experience and exceptionally good references.

  *Fellowships:* Two special fellowships (the USAF fellowships) are available to U.S. citizens and permanent residents and are sponsored by AFOSR. A Ph.D. program is also available through a local university. The Air Force provides two $15k fellowships paid directly to VKI each year, the funds are given to the students to offset travel and living expenses. There is no tuition fee at VKI for students from NATO countries.

  *How to Apply:* Applications for the USAF fellowships are made directly to the Director of VKI. Academic records are key discriminators. Selected applications are then forwarded to AFOSR for evaluation and final selection.

The VKI website is http://www.vki.ac.be/. Information may also be obtained from EOARD, Dr. Charbel Raffoul.

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*Lt. Col. (sel) Jerry J. Sellers*
*Astronautics*

**Site Visit: Centre de Physique des Plasmas et de Leurs Applications de Toulouse (CPAT), Universite Paul Sabatier, Toulouse, France, 1 March 2000.** Jean-Pierre Boeuf and Leanne Pitchford hosted the visit. The Center of Plasma Physics and Applications of Toulouse is a laboratory on the campus of the University Paul Sabatier. The CPAT is sponsored jointly by the French National Center for Scientific Research and the University Paul Sabatier. The permanent research staff is 50% CNRS researchers and 50% University professors. CPAT was created in the 1960's with the original activities centered on atomic physics. Since its creation, research activities have evolved progressively toward the physics of low temperature plasmas and electrical discharges. Current CPAT research is focused on the physics and chemistry of plasmas produced in electric discharges. Activities of the CPAT can be grouped into:

- Modeling non-equilibrium plasmas
- Thermal plasmas and radiation
- Discharges in reactive environments

Discussions focused on efforts by the CPAT team to model the behavior of Stationary Plasma ("Hall Effect") Thrusters (SPT). These electric thrusters are gaining increased attention for a variety of applications on future commercial and DoD spacecraft for orbit maneuvering and station keeping. AFRL has similar modeling efforts with the Propulsion Directorate at Edwards AFB. The purpose of the visit was to determine topics of mutual interest for possible future research contracts. Several topics identified:

- Basic model comparisons
- Applications of models low power scaling
- Comparison of hybrid models to various analytical approaches
- Modeling and empirical results of interaction studies on the upcoming French STANTOR spacecraft which will operate a 1.3 kW SPT.

Further discussions between EOARD, AFRL/PR and CPAT are planned in the coming months to converge on a likely topic for additional study.

**Site Visit: Department of Physics & Astronomy, Condensed Matter and Materials Physics Group, University College London, UK, 18 April 2000.** Prof. Marshall Stoneham hosted the visit. Established in 1993, the Condensed Matter and Materials Physics group has expanded rapidly. It now has 60 members, including 14 academic staff and 20 Ph.D. students in addition to postdoctoral, technical, and support staff. The group includes both experimentalists and theorists with wide-ranging research interests. Topics range from the physics of high pressure ices to the properties of novel magnetic materials, from the temperature in the Earth's core to atomic-scale microscopy, and from the structure of liquids in solutions and at interfaces to colloids and the dynamics of enzymes. The group also is an integral part of the University's Centre for Materials Research (CMR). The CMR involves eight departments within the College as well as the Royal Institution of Great Britain. It provides a focus for the wide-ranging materials science and engineering at UCL linking departments and disciplines and including both physical and biological sciences. Among its main themes are simulation and modeling, surfaces and interfaces, thin films, and disordered systems like glasses, liquids and colloids. Major focuses are modeling and diffraction methods. Modeling covers length scales from atomic to macroscopic via the mesoscopic scale critical in many applications like friction and wear. The emphasis is on processes as well as structures. An aim is to cover whole-process modeling with much of the work having industry links. Studies include embedding techniques for defects and impurities, nanoclusters; materials modification by excitation; novel applications of scanning probe microscopy; simulations of heterointerfaces; industrial thermal barrier coatings and diamond films; aerosol physics, e.g. nucleation of droplets from vapors; reverse Monte Carlo modeling of aqueous solutions; polarized gamma-ray techniques in magnetism; and ultrafine hard and soft magnetic particles.

The purpose of the visit was to review the progress on work being conducted by Dr. Alex Shluger titled "First principle calculations of electrical levels for radiation induced defects in amorphous $SiO_2$" under contract with EOARD and jointly funded by AFRL/VSSE. The AFRL point of contact for the work, Dr. Art Edwards from AFRL/VSSE, accompanied me on the visit. Dr. Edwards visited the department for several days to do an in-depth assessment of the program status. The objectives of this project are:

1) To develop an embedded cluster method for calculations of the electronic structure and spectroscopic properties as well as electron affinities and ionisation potentials of point defects in crystalline and amorphous silica; and
2) To study the geometric electronic structure, stability and properties of proton and H- centres in a-quartz and a-SiO2.

Fundamentally, the research is trying to understand the effects of radiation on silicon-based electronics to further the development of radiation-hardened electronics for space applications. Work is progressing well and the first deliverable on the contract has been accepted. For specific questions about AFRL radiation-hardened electronics research effort, contact Dr. Edwards (edwardsa@plk.af.mil).

**Site Visit: Hymatic Engineering Company, Ltd., Near Birmingham, UK, 19 April 2000.** The visit was hosted by Mr. Chris Aubon, Technical Manager and Dr. Thom Davis, AFRL/VS, who oversees the AFRL cryocooler research program, attended. Hymatic is working closely with Prof. Gordon Davey's research group at Oxford University, UK on improvements to cyrocooler pumps by vibration minimization on balanced compressor designs in an effort to model and understand critical design and manufacturing sensitivities. During the visit, Hymatic and Oxford researchers gave a detailed review of their joint work and how it ties into on-going AF programs. We were also given a tour of Hymatic's impressive design and manufacturing facilities. As a company, Hymatic has been at the forefront of the design and manufacture of in Joule-Thomson cooling technologies for infrared applications. More recently, the company has focused on the development of Stirling Cycle Cryocoolers for very long lifetime cooling devices suitable for applications within industrial, communications and space environments. In 1999, the 270-employee company had a turnover of $37M at their purpose-built facility outside Birmingham. Approximately 21% of their business is involved with the repair and overhaul of existing equipment, 60% for fluid control technologies (mainly for air), and 23% for cyrogenics technologies. Approximately 72% of their business is defense-related; the remainder is primarily civil aviation. For additional information on the AFRL cryocooler research program, contact Thom Davis (thom.davis@kirtland.af.mil).

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*Dr. Martin Stickley*
*Lasers, Optics and Materials*

**Site Visit: Ben Gurion University of the Negev, Be'er Sheba, Israel.**
**Coil Laser**: Dr. Salman (Zamik) Rosenwaks (zamik@bgumail.bgu.ac.il) and BGU have had a Data Exchange Agreement with the AFRL for some time in the area of chemical oxygen-iodine lasers (COIL), especially the use of a tunable diode laser for diagnosing internal operating parameters within the laser medium. In a COIL, iodine is usually injected into a mixture of excited oxygen and buffer gas just before the mixture undergoes a supersonic expansion. Rosenwaks and his group have found that mixing the iodine at or after the critical cross section allows operation at higher chemical efficiency without buffer gas. They are currently carrying out detailed diagnostics of the operation of this laser under these conditions and use a tunable diode laser source as a diagnostic.

**Laser Satellite Communications**: Dr. Shlomi Arnon (shlomi@ee.bgu.ac.il) has been working with Dr. N. Kopeika (see Feature Article) in the area of laser satellite communications. They have developed adaptive communication methods where data rate is varied adaptively with atmospheric conditions to provide low bit error rate links. This has been verified through Monte Carlo simulation. Efforts are under way to develop actual links for optical communication through the atmosphere in order to show their feasibility for satellite communication. Effects of satellite vibration on bit error rate have also been studied.

**Solar Cells and Concentrators**: Dr. David Faimann (faimann@bgumail.bgu.ad.il) is located at the Institute for Desert Research at the Sede-Boqer Campus located some 30km south east of Be'er Sheba, and he gave me a tour of the solar energy R&D being conducted there. They generate electricity from solar cells of various types and deliver it onto the electrical grid in Israel. Faimann has made an extensive assessment of the economics of this and has concluded that electricity generated with solar cells will never be economical (at least in Israel). He believes the cost of the hardware into which the cells are installed and for converting the low voltage and high current to that suitable for the electrical grid will cost as much as the electricity can be sold for. Thus there is no margin left for purchase of the cells. While they continue to test and develop solar cells (such as those made from buckeyballs) and evaluate the factors limiting their lifetime, they are moving in the direction of developing large circular parabolic solar collectors (25 meters in diameter) to focus the collected energy onto solar cells. They expect that this approach will be economical as it leverages the knowledge and prior investment in building dishes for antennas.

They have been developing new optical systems for concentrating solar radiation to ultrahigh levels and for delivering concentrated sunlight with extreme uniformity. Applications include high efficiency thermal power generation, solar-pumped lasers, solar production of clean fuels, chemical storage of concentrated solar radiation, and photovoltaic power production where the issue of delivered flux uniformity is critical. Interestingly, they realize that they are confronted with considerations of brightness and transfer of power rather than image fidelity. Such applications include fiber optic coupling, radiant heating, projection, solar energy, illumination, and detection. Nonimaging optics is a new design approach that departs from the methods of traditional optical design to develop new techniques for maximizing the collecting power of concentrator and illuminator systems. Nonimaging devices substantially outperform conventional lenses and mirrors in these applications.

**Site Visit: Technion- Israel Institute of Technology, Technion, Israel**. Profs. Gad Bahir (bahir@ee.technion.ac.il) and Eliezer Finkman (finkman@ee.technion.ac.il) of the Solid State Institute and Microelectronics Research Center showed me extensive materials deposition (advanced MOMBE epitaxial system) and characterization capabilities for making microelectronic InP-based devices including IR focal plane detectors. They have suggested that the next step forward in Quantum Well focal planes would be to use Quantum Dots (QD). A detector array formed from these would offer superior signal-to-noise ratio performance compared to Quantum Well focal planes and would lead to simplified two-color detection. An earlier limit on forming QDs has been overcome by the development of a technique based on self-organized growth of QDs due to the large lattice mismatch between two semiconductor components that gives rise to the spontaneous formation of nanoscale islands. Their facilites were very impressive, and had been largely donated by friends of the Technion. One other faculty member I visited said that within the past 12 months, the Technion had been given at least $20M for optics alone!

**Conference: 5th International Conference on Organic Nonlinear Optics, Davos, Switzerland, 12-16 March, 2000**. Some 200 chemists and physicists attended this fifth international conference devoted to the latest results in organic materials applied to nonlinear optical applications, especially electro-optical modulators, and WDM components. Attendees were there from around the world: the US, Korea, Japan, Russian, France, Portugal, the UK, etc. Organic materials have always looked attractive because (a) they are potentially low in cost, (b) their nonlinear coefficients are enormous which should lead to low drive voltages, and (c) their dielectric constants are fairly uniform in frequency which can lead to devices with large bandwidths. While cost was not particularly discussed, there were reports of a push-pull, Mach-Zehnder, three centimeter long modulator having a drive voltage of less than one volt to achieve a pi phase shift for a one micron laser beam. This is impressive performance, but there are still concerns about the long term stability (i.e. lifetime) of such materials. A number of papers were given relating to optical limiters, devices that have a nonlinear transmission of light intensity such that at high intensities they limit the flux thus reducing the probability of damage to sensors. The biggest market, however, still appears to be light-emitting diodes for traffic lights and displays for consumer applications.

**Site Visit: Ecole Polytechnique Federal de Lausanne (EPFL) (Swiss Federal Institute of Technology), Lausanne, Switzerland, 1 May 2000.** Representatives of EOARD visited Professor Michael Graetzel (michael.graetzel@epfl.ch) and his team at their Lausanne laboratories to review their R&D results and concepts in the area of dye sensitized solar cells (DYSCs), and their ideas for advanced versions of this technology that may someday provide electrical power to remote USAF sites. DYSCs are one of the few alternatives to semiconductor pn junction-type devices to serve as solar cells. Graetzel's group has produced a liquid cell that is 10.4% efficient when tested in Air Mass 1.5 global solar radiation with 1000 watts/ $m^2$ of incident intensity and has licensed this to seven industrial firms. Its promise is low cost since high purity semiconductors are not needed. Their device does not require collection of minority carriers (ie, it is a majority carrier device), and can operate at elevated temperatures (70 degrees Centigrade) without the loss of efficiency that is typical of semiconductors. They are pursuing the development of solid heterojunction variants of the DYSC that have potential for further cost reduction and simplification of the manufacturing of the solar cells. A recent article summarizes their progress and directions for further development: "Perspectives for Dye-Sensitized Nanocrystalline Solar Cells," Prog. Photovolt. Res. Appl. 8, 171-185 (2000).

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*Mr. Jay Howland*
*Physics and Energetic Materials*

**Site Visit: OPTOPAL Panoramic Metrology Consulting, Budapest, Hungary, 4 Apr 2000.**
Dr. Pal Greguss director of OPTOPAL Panoramic Metrology Consulting organized the meeting where the principal topic was recent progress on developing a 360-degree panoramic annular lens. The goal of this feasibility study is to find out whether the performance of a PAL-optic, similar to that used in the PAL Attitude Determination System (PALADS) of the microsatellite SEDSAT-1 launched on October 24, 1998, could be improved and then adapted as a vision module for military systems. The military video systems being considered are azimuth determination system (ADS), sniper fire location display (SFLD), and helicopter blade tracking system (HBTS). The successful use of a PAL-based vision module depends upon several factors. First, the optical design of the PAL itself with respect to the technical realization of the system in question has to take into account how the virtual panoramic image created inside the glass block of the PAL could be projected onto the image sensor of the given video system. Another crucial factor is how the virtual 360 degree panoramic image displayed in polar coordinates can be evaluated, e.g., how it conveys

azimuth information or how it can be converted into Cartesian coordinates, which means “straightening out” the ring shaped image.

**Site Visit: SzTAKI, Budapest, Hungary, 6 Apr 2000.** Dr. Tamas Roska, SzTAKI Program Manager, briefed on the final results of the Super-fast Intelligent Target Evaluation (SITE) EOARD contract. Recently, dramatic failures in military and industry have proved the vulnerability of present day sensor-computer technologies. In spite of witnessing the current sensor-revolution, the integration of multimodal sensor arrays and computers are in their infancy. In this project, following successful theoretical and experimental work on a new computer paradigm, called analogic (combining analog array dynamics and logic) cellular (CNN) computers and related technologies, a major effort is planned to achieve a new level of quality and computing power in the sensor computer arena. High-speed target recognition and tracking systems are improved by removing the bottleneck caused by the separation of sensing and computing due to the analog sensing and digital processing.

In the new sensor-computer framework, a genuine dynamic interaction of the two processes is integrated, mimicking the most successful living creatures. Analogic cellular computers have become not only a theoretical interest but a neuromorphic modeling tool. The measured TeraOPS computing power, in a focal plane CNN universal machine chip with 4096 processors using a 0.5 micron standard CMOS technology, on 1 $cm^2$ at 1 W, manifested a beginning of a new era in sensory array computers. In addition, a target detection experiment achieved 10,000 frames per second using these chips in a test system.

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*Major Tim Lawrence*
*Space Technology*

**Site Visit**: **Rutherford Appleton Laboratories, Chilton, Didcot, United Kingdom, 8 March 2000.** Dr Mireille Levy introduced the Radar Communications Group, 50 people who are concentrating their research on radar performance prediction. They have developed a 2D code used to predict radar duct holes on helicopters. This code is currently in use by the RAF and allows the pilots to change course to correct for radar the error caused due to this duct effect. Dr Richard Holloway introduced the 200-person Space Department. Their research focus is on scientific instruments for space science missions. Dr Holloway currently has 40 customers, 140 projects, and a total research budget of 17 million pounds. Their biggest customer is the European Space Agency who has worked with them on space environment and instrumentation projects.

**Conference: 4th Conference on Liquid Space Propulsion, Lampoldshausen, Germany, 12 – 15 March 2000**. EOARD and AFOSR sponsored the 4th Conference on Liquid Space Propulsion in Lampoldshausen Germany. The conference consisted of 34 papers involving 80 attendees from 9 countries. The conference focused on advanced chemical combustion concepts, combustion chamber physics, advanced launch vehicles, and injector design. The research highlights were the improved Ariane V design scheduled for the operational fleet in 2006. The updated launcher is expected to double its current 6-ton payload launch capability to geosynchronus orbit.

**Site Visit: Laser propulsion lab at DLR Stuttgart, Germany, 17 March 2000.** Dr Willy Bonn presented his on-going research in laser propulsion, which focuses laser energy onto a parabolic dish and so detonates the atmosphere and pushes the object forward/upward. This concept is similar to the program being conducted under Dr Franklin Mead of Edwards AFB. Dr Bonn has been the first to use laser fluorescence to predict the shock wave behavior of the detonation and has compared the results to detonation theory. Dr Bonn plans on continuing the work and is interested in studying the impact of varying the ambient pressure to determine the exact atmospheric density where detonations will not occur.

**Meeting: Visit composite spacecraft bus development facility, Technical University of Munich, Germany, 19 – 21 March 2000.** Dr Peter Eckert introduced his small satellite design team, an ambitious group of 40 students and professors planning a low-cost lunar mission. Their design calls for sending a 100-kg platform from an Ariane V to investigate possible ice samples in the lunar polar region from a 60-km orbit. Unfortunately, there currently is no support for such a mission, but the TU Munich team is actively looking for collaborating partners in composite structures for spacecraft application and system engineering modeling for low-cost small satellite missions.

**Meeting: Sophradir, Paris, France, 31 March 2000**. The primary host and POC was Dr Alain Manisidjian. Dr Allan Hahn and Dr Frank Roush of AFRL/VS also attended this meeting on the development of

Sophradir's infra-red detectors for space satellite systems. Although new to the space arena, their systems look promising for future space missions.

## CONFERENCE SUPPORT

EOARD promotes technical interchange by supporting and co-sponsoring technical workshops and mini-symposia at overseas conferences. We often receive in return proceedings and attendance for one or more Air Force representatives. Air Force R&D personnel attending or considering attending European conferences should contact EOARD for further information. For further details on the conferences below contact the program manager indicated (see footnotes). **Bi-service and tri-service support efforts are in bold print.**

| *Dates (2000)* | *Location* | *Conference/Workshop Title* | *LO*[1] |
|---|---|---|---|
| **17 - 23 May 00** | **Antalya, Turkey** | **The Tenth International Symposium on Equatorial Aeronomy http://sky.ece.uiuc.edu/isea10/** | **JJS** |
| 23 - 25 May 00 | Catania, It | 6th Intl. Workshop on Cellular Neural Networks & Applications | JAH |
| 30 May - 3 Jun 00 | St. Petersburg, Russia | Thermochemical processes in plasma aerodynamics Not yet | CNR |
| 30 May - 2 Jun 00 | Edinburgh Int'l Conference Centre, Scotland | EUROEM 2000 | CMS |
| 30 May 00 | Vienna, Austria | Comparative & Veterinary Electrophysiology of Vision | RSF |
| 31 May - 2 Jun 00 | Stuttgart, Germany | Workshop on Thermal and Environmental Barrier Coatings | RSF |
| 8 - 9 Jun 00 | Berlin, Germany | Aerospace Technologies of the XXI Century New Technologies of Experimental Research & Simulation http://www.ila-berlin.com/vers2/index-j.html | CNR |
| 12 - 14 Jun 00 | Dniepropetrovsk, Ukraine | Eutectica V http://www.dmeti.dp.ua/eng/eutect.html | RSF |
| 14 - 16 Jun 00 | Ajaccio (CORSICA) | ATW - Advance Technology Workshop http://ura2053.univ-corse.fr | CR |
| 18 - 23 Jun 00 | Sigtuna, Sweden | Nordic Symposium on Computational Biology http://www.agora.kva.se/meetings/CompBio2000 | RSF |
| **18 - 28 Jun 00** | **Kiev, Ukraine** | **Functionally Gradient Materials and Surface Layers Prepared by Fine Particles Technology** | **RSF** |
| **19 - 29 Jun 00** | **Hersonissos, Greece** | **Advanced Study Institute on Space Storms and Space Weather Hazards http://sat2.space.noa.gr/~daglis/asi2000.html** | **JJS** |
| **19 - 22 Jun 00** | **Stresa, Italy** | **5th-ISICP Combustion of Energetic Materials N/A** | **JAH** |
| **19 - 24 Jun 00** | **Limassol, Cyprus** | **Multiscale Materials Phenomena in Harsh Environments** | **RSF** |
| 21 - 28 Jun 00 | Chateau de Bonas, near Toulouse, France | NATO Advanced Research Workshop: Terahertz Sources and Systems http://www.imp.leeds.ac.uk/nato/ | DMB |
| 21 - 23 Jun 00 | PORTO Portugal | VECPAR - 4th International Meeting on Vector and Parallel Processing http://www.fe.up.pt/vecpar2000 | CR |
| 26 - 30 Jun 00 | St. Petersburg, Russia | Tenth Conference on Laser optics email: conf2000@ilph.spb.su | CMS |
| 26 - 29 Jun 00 | Marathon, Greece | ADVANCED MAGNETIC MATERIALS FOR MORE-ELECTRIC MILITARY VEHICLES AND ELECTRIC PULSE POWER SYSTEMS(AVT-060) N/A | DMB |
| **26 - 28 Jun 00** | **Cambridge Univ, UK** | **Materials Engineering - a Forward Look (The Ashby Symposium)** | **RSF** |
| **27 - 30 Jun 00** | **Karlruhe, Germany** | **International Conference on Energetic Materials** | **JAH** |
| 27 - 30 Jun 00 | Barcelona, Spain | Eighth European Turbulence Conference (ETC8) http://etc8.litec.csic.es/ | CNR |
| 27 - 29 Jun 00 | Royal Aeronautical Society, London, UK | Fourth Test & Evaluation International Aerospace Forum none yet | CNR |
| 2 - 15 Jul 00 | Castelvecchio Pascoli (Lucca), Italy | 20th Century Harmonic Analysis http://www.cs.umb.edu/~asi/analysis2000 | CMS |
| **5 - 7 Jul 00** | **UMIST Conf Centre, Manchester UK** | **Polymer Fibres 2000** | **RSF** |
| 9 - 15 Jul 00 | Novosibirsk, Russia | International Conferences on Methods of Aerophysical Research (ICMAR'2000) http://www.itam.nsc.ru/icmar2000/ | CNR |
| **10 - 12 Jul 00** | **Oxford, UK** | **Sixth International Conference on Residual Stress** | **RSF** |
| **10 - 13 Jul 00** | **Lisbon, Portugal** | **Tenth International Symposium on Applications of Laser Techniques to Fluid Mechanics http://in3.dem.ist.utl.pt/lisboa-laser/** | **CNR** |
| 16 - 21 Jul 00 | Ecole Nationale Superieure, Bordeaus, France | 9th Int'l Workshop on Laser Physics - LPHYS 2000' | CMS |

| *Dates (2000)* | *Location* | *Conference/Workshop Title* | *LO*[1] |
|---|---|---|---|
| 16 - 19 Jul 00 | Tomsk, Russia | 7 International Symposium on Atmospheric and Ocean Optics | JAH |
| **8 - 10 Aug 00** | **Pretoria, South Africa** | **International Workshop on Multidisciplinary Design Optimization www.me.up.ac.za/mdog** | **CNR** |
| 21 - 23 Aug 00 | St. Petersburg, Russia | Nonresonant Laser- Matter Interaction 10 | CMS |
| 21 - 23 Aug 00 | Mjärdevi Science Park, Linköping, Sweden | Tenth European Conference on Cognitive Ergonomics (ECCE-10) http://www.iav.ikp.liu.se/ecce10/ | RSF |
| 27 - 31 Aug 00 | Groningen, the Netherlands | European Conference on Visual Perception http://www.ecvp.org | GTO |
| **28 Aug - 1 Sep 00** | **Brijuni island - Croatia** | **Brijuni conference - Important problems for the XXI century http://www.brijuni-conference.irb.hr** | **JJS** |
| 4 - 7 Sep 00 | Bucharest, Romania | 6th Conference on Optics: "Romopto 2000" | CMS |
| 11 - 14 Sep 00 | World Trade Center, Barcelona, Spain | European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2000) http://www.cimne.upc.es/eccomas | CNR |
| 11 - 14 Sep 00 | Barcelona, Spain | COMPLAS 2000 Computational Plasticity: Fundamentals & Applications http//www.cimne.upc.es/eccomas | RSF |
| 18 - 22 Sep 00 | Katseveli-town, Crimea, Ukraine | Materials and Coatings for Extreme Environments Performance www.materials.kiev.ua:8101/IPMS/?LANG=en&PAGE=events | RSF |
| 18 - 22 Sep 00 | Florence, Italy | XIII Int'l Symposium on Gas Flow & Chemical Lasers and High Power Laser Conference | CMS |
| 20 - 22 Sep 00 | Kiev, Ukraine | Organized Vortical Motion as a basis for Boundary-Layer Control http://iprinet.kiev.ua/vortex .htm | CNR |
| 24 Sep - 3 Oct 00 | Yerevan, Armenia | "Cellular Mechanism of Beneficial and Harmful Effects of Electromagnetic Fields" | CMS |
| 25 - 27 Sep 00 | Pisa, Italy | Condition-Based Maintenance for Highly Engineered Systems | RSF |
| 27 - 29 Sep 00 | Amsterdam | How eye movements serve the needs of vision in the natural world | GTO |
| 2 - 6 Oct 00 | Crimea, Ukraine | Singular Optics: Fundamentals & Applications | CMS |
| 9 - 13 Oct 00 | Zakopane, Poland | Int'l Conf. On Solid State Crystals - Materials Science and Applications | CMS |
| **16 - 18 Oct 00** | **Cranfield, UK** | **Medical and Engineering Aspects of Dynamic Head and Neck Injuries** | **RSF** |
| **11 - 12 Dec 00** | **Birmingham, UK** | **Titanium Alloys at Elevated Temperature www.materials.org.uk** | **RSF** |
| 20 - 25 May 01 | Capri, Italy | Optimization in Composite Material Design and Structural Integrity | RSF |

[1] CMS-Martin Stickley; CNR-Charbel N. Raffoul; GTO-Gerald T. O'Connor; JAH-Jay A. Howland; JJS-Jerry J. Sellers; RSF-Robert S. Fredell;TL-Tim Lawrence

## WINDOW ON SCIENCE

EOARD initiates and promotes technical liaison between Air Force and foreign scientists very effectively with the Window On Science (WOS) program, through which we can arrange and fund visits of foreign scientists to selected Air Force facilities. To nominate a WOS candidate, contact your Technical Director or your EOARD discipline representative. WOS visitors currently on contract are listed below. For further details contact the program manager indicated (see footnotes). **Bi-service and tri-service coordinated visits are in bold print.**

| *Dates (1999)* | *Traveler* | *Country* | *Topic* | *Location(s) of Visit*[1] | *LO*[2] |
|---|---|---|---|---|---|
| 1 - 10 May 00 | Professor Habil Andras Lorincz | Hungary | Neural networks | AFRL/IF Rome AFB, NY; AFRL/IF, San Diego, CA; Princeton University, NJ | CR |
| 1 May - 3 Jun 00 | Mr. Hugues Richard | Germany | Rotorcraft Aerodynamics | NASA Langley; NASA Ames | CNR |
| **3 - 14 May 00** | **Ms. Anca Gabriela Mocofanescu** | **Romania** | **Optical fibers as phase conjugate mirrors** | **AFRL/DELO, Kirtland AFB, NM, and San Francisci, CA.** | **CMS** |
| 6 - 27 May 00 | Mr Kevin MacDonald | United Kingdom | Optical nonlinearity at thin film interfaces | US Air Force Academy, Colorado Springs, CO | CMS |
| **7 - 20 May 00** | **Dr. Petr G Zverev** | **Russia** | **Color center lasers for pumping narrow line gases in the mid-IR** | **San Francisci, CA; Salt Lake City, UT; and AFRL/DELC, Kirtland AFB, NM** | **CMS** |
| 9 - 18 May 00 | Dr. Boris Malomed | Israel | Dispersion management | AFRL/DELO, Kirtland AFB, NM | CMS |

| Dates (1999) | Traveler | Country | Topic | Location(s) of Visit[1] | LO[2] |
|---|---|---|---|---|---|
| | | | in optical fibers | | |
| 10 - 19 May 00 | Mr. Johannes de Rijck | the Netherlands | Simplified Approach for Stress Analysis of Mechanically Fastened Joints | AFRL/VA, Wright-Patterson AFB DoD/NASA/FAA Aging Aircraft Conference, St Louis MO | RSF |
| 12 - 20 May 00 | Prof. Richard Pethrick | United Kingdom | Application of Dielectric Analysis to Investigation of Ageing in Adhesive Bonded Structures | AFOSR polymer programs review, Long Beach, CA | RSF |
| 13 - 20 May 00 | Ms Galina Lebedeva | Russia | Aerospace materials | AFRL/DE, Kirtland AFB, NM | JJS |
| 13 - 20 May 00 | Dr. Sergey Khatipov | Russia | Aerospace materials | AFRL/DE, Kirtland AFB, NM | JJS |
| 13 - 20 May 00 | Dr. Luigi Foschini | Italy | Meteoroid hazard to satellites | AFRL/VS, Hanscom AFB, MA | CMS |
| 14 May - 3 Jun 00 | Dr. Markus Raffel | Germany | Rotorcraft Aerodynamics | NASA Langley; NASA Ames | CNR |
| 16 - 25 May 00 | Dr Svetlana Kapustnikova | Ukraine | in-situ titanium eutectic composites | Institute for Problems in Materials Science, Kiev | RSF |
| 16 - 25 May 00 | Professor Vladyslav Mazur | Ukraine | in-situ titanium eutectic composites | Institute for Problems in Materials Science, Kiev | RSF |
| 17 - 25 May 00 | Dr Giuliano Marino | Italy | Thermal Oxidative Stability of IM7/5250-4 BMI Composites | Long Beach, CA | RSF |
| 18 May - 21 Jun 00 | Tatiana Pikus | Russia | Plasma Physics | ICOPS 2000 conference, New Orleans, Louisana | JAH |
| 18 - 25 May 00 | Dr. Serguei Skobelev | Russia | Russian scientists developing hybrid Yagi-Uda antennas meet with Hanscom Research Site Scientists | Hanscom Research Site & IEEE International Conference on Phased Array Systems and Technology San Diego, CA | DMB |
| 18 - 25 May 00 | Dr Alexander V. Shishlov | Russia | Russian scientists developing hybrid Yagi-Uda antennas meet with Hanscom Research Site Scientists | Hanscom Research Site & IEEE International Conference on Phased Array Systems and Technology San Diego, CA | DMB |
| 18 May - 14 Jun 00 | Dr. Anatoly Faenov | Russia | Plasma Physics | ICOPS 2000 conference, New Orleans, Louisana | JAH |
| 21 - 26 May 00 | Dr. Alexander Tchourenkov | Russia | Fibre Optics | Rome AFRL NRL | CR |
| 24 - 27 May 00 | Dr Volodymyr I Kyryschuk | Ukraine | Optimization of 178m2Hf isomer production | EOARD, London, England | CMS |
| 24 - 26 May 00 | Dr. Jean-Michel Pouvesle | France | Flash x-rays systems for research on induced gamma emission | Edison House, London, England | CMS |
| 29 May - 2 Jun 00 | Dr. Andrei Repin | Russia | Plasma Physics & Magnetohydrodynamics | Euro Electromagnetics 2000 conference Edinburgh Scotland | JAH |
| 29 May - 2 Jun 00 | Professor Evgueni Stoupitski | Russia | Plasma Physics & Magnetohydrodynamics | Euro Electromagnetics 2000 conference Edinburgh Scotland | JAH |
| 31 May - 10 Jun 00 | Professor Per E Sandholt | Norway | Atmospheric RF Propagation | AFOSR, Washington, DC | DMB |
| 3 - 8 Jun 00 | Dr Ryszard Miklaszewski | Poland | Plasma Physics | ICOPS 2000 conference, New Orleans, Louisana | JAH |
| 3 - 8 Jun 00 | Professor Marek Sadowski | Poland | Plasma Physics | ICOPS 2000 conference, New Orleans, Louisana | JAH |
| 3 - 10 Jun 00 | Professor Boris Briskman | Russia | Space matierals testing | International Standards Organization meeting, London, UK. | JJS |
| 3 - 8 Jun 00 | Dr Marek Scholz | Poland | Plasma Physics | ICOPS 2000 conference, New Orleans, Louisana | JAH |
| 5 - 17 Jun 00 | Prof. Eberhard Gruen | Germany | Interplanetary dust | AFRL/VS at HRS | CMS |
| 10 - 17 Jun 00 | Dr Brian White | United Kingdom | Micro air vehicles, swarm theory | Munitions Directorate, Eglin AFB and AFOSR | RSF |
| 10 - 14 Jun 00 | Dr Rafal Zbikowski | United Kingdom | Micro air vehicles and swarm theory | Munitions Directorate, Eglin AFB and AFOSR | RSF |
| **13 - 22 Jun 00** | **Dr. Anatoli Alexandrovich** | **Russia** | **Hypersonic Boundary Layer Interaction** | **NASA Dryden; Denver CO.** | **CNR** |

| *Dates (1999)* | *Traveler* | *Country* | *Topic* | *Location(s) of Visit*[1] | *LO*[2] |
|---|---|---|---|---|---|
| | **Maslov** | | | | |
| **13 - 23 Jun 00** | **Dr. Valeri Nikolaev** | **Russia** | **Efficient supersonic COIL** | **AIAA Meeting, Denver, CO., and AFRL/DELC, Kirtland AFB, NM** | **CMS** |
| 13 - 19 Jun 00 | Dr. Pierre Villars | Switzerland | Materials modeling | AFRL/ML Wright-Patterson, AFB, OH | JJS |
| **13 - 22 Jun 00** | **Professor Jean Delery** | **France** | **Flow Control at ONERA** | **NASA Dryden, USAFA** | **CNR** |
| **14 - 26 Jun 00** | **Professor Ya. Volf Borovoy** | **Russia** | **Shock/Shock Interference at Hypersonic Speeds** | **Denver, USAFA, CO** | **CNR** |
| **15 - 22 Jun 00** | **Dr. Didier Marcel Jean Barberis** | **France** | **Flow Control at ONERA** | **Denver, USAFA, WPAFB** | **CNR** |
| **15 - 22 Jun 00** | **Dr. Reynald Stephan Jules Bur** | **France** | **Flow Control at ONERA** | **Denver, USAFA, WPAFB** | **CNR** |
| 18 - 28 Jun 00 | Mrs. Victoria A Koulkova | Russia | Simulation of thrust-vectored flight | Virginia Beach, VA and WPAFB, OH | GTO |
| 19 - 29 Jun 00 | Professor John Plane | United Kingdom | The impact of extra-terrestrial dust on the upper atmosphere | AFRL/VS, HRS | CMS |
| **26 - 30 Jun 00** | **Dr. Francois Falempin** | **France** | **Scramjet test facilities in France** | **London, UK** | **CNR** |
| **27 - 29 Jun 00** | **Professor Mario Carbonaro** | **Belgium** | **Plasmatron Facility at VKI** | **London, UK** | **CNR** |
| **9 - 20 Jul 00** | **Professor Fadl Moukalled** | **Lebanon** | **Computational Fluid Dynamics (CFD)** | **AFRL/WPAFB, LSU, Huntsville** | **CNR** |
| 15 - 21 Jul 00 | Assoc. Professor Eva Acosta Plaza | Spain | Curvature sensing for retrieving turbulence-induced phase distortions | AFLR/DEBS, Kirtland AFB, NM | CMS |
| **16 - 27 Jul 00** | **Professor Ioannis Hardalupas** | **United Kingdom** | **Combustion** | **Edwards AFB, Wright Patterson AFB, NASA Glenn** | **CNR** |
| 29 Jul - 21 Aug 00 | Dr. Adrian Stern | Israel | Restoring images degraded by motion | AFRL/DEBS, Kirtland AFB, NM., and San Diego, CA. | CMS |
| 30 Jul - 10 Aug 00 | Ms. Shirly Winnikamien-Pinhasi | Israel | High resolution optical curvature sensing | SPIE in San Diego, CA and AFRL/DEBS, Kirtland AFB, NM | CMS |
| **19 - 23 Aug 00** | **Dr. Odayarkoil Natarajan Ramesh** | **United Kingdom** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| **19 - 23 Aug 00** | **Dr. Howard Hodson** | **United Kingdom** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| **19 - 23 Aug 00** | **Dr. Anthony Mark Savill, Prof. Frank Smith, Dr. Mark Wyatt Johnson, Prof. Ian Poll, Prof. Jonathan Gostelow, Prof. Ricardo Fernando Martinez Botas Mateo,** | **United Kingdom** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| **19 - 23 Aug 00** | **Prof. Erik Dick** | **Belgium** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| **19 - 24 Aug 00** | **Professor Torsten H Fransson** | **Sweden** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| **19 - 23 Aug 00** | **Dr. Johan Steelant** | **The Netherlands** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| **19 - 23 Aug 00** | **Dr. Vassilios Theofilis** | **Germany** | **Boundary Layer Transition & Turbomachinery Flows** | **Minnowbrook, NY** | **CNR** |
| 30 Aug - 9 Sep 00 | Dr. Afzal Suleman | Portugal | Adaptive materials for aerodynamic flutter | AFRL/VA, Wright-Patterson AFB, OH | JJS |

| *Dates (1999)* | *Traveler* | *Country* | *Topic* | *Location(s) of Visit*[1] | *LO*[2] |
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| | | | supression | | |
| 9 - 16 Sep 00 | Dr. Christopher J. Solomon | United Kingdom | Modeling adaptive optics systems | AFRL/DEBS, Kirtland AFB, NM | CMS |
| 10 - 23 Sep 00 | Professor Alexey Ustinov | Germany | Applied Superconductivity | HRS, MIT, NRL, Applied Superconductivity Conference, Virgina Beach | CR |
| 11 - 15 Sep 00 | Dr. Shlomo Arnon | Israel | Laser satellite communication networks | AFRL/DE, Kirtland AFB, NM | CMS |
| 12 - 19 Sep 00 | Dr. Nadejda Kiselyova | Russia | Modeling of inorganic materials | Inorganic Materials Conference, Santa Barbara, CA., AFRL/ML Wright-Patterson AFB, OH | JJS |
| 16 - 29 Sep 00 | Associate Professor Hamid Reza Kokabi | France | Dr Kokabi presents latest research results on superconductivity; Possible year long sabbatical visit | 1. Applied Superconductivity Conf -- Virginia Beach, VA (17-22 SEP); 2. Hanscom Research Site (24-27 SEP); 3. AFOSR Headquarters-- Washington DC (28 SEP) | DMB |
| 30 Sep - 5 Oct 00 | Dr. Nadejda Kiselyova | Russia | Materials Modeling | Artificial Intelligence in Real Time Control 2000 Conference, Budapest, Hungary | JJS |
| 1 Oct 00 | Mr. Volker Fleck | France | Magnetic Sensors for Munitions | AFRL/MN | CNR |

[1] AFRL Research Sites–**ARS**: Armstrong Research Site, Brooks AFB, TX; **ERS**, Edwards Research Site, Edwards AFB, CA **HRS**: Hanscom Research Site, Hanscom AFB, MA; **PRS**: Philips Research Site, Kirtland AFB, NM; **RRS**, Rome Research Site, Rome, NY; **WRS**: Wright Research Site, Wright-Patterson AFB, OH; Other sites: **AEDC**: Arnold Engineering Development Center, Arnold AFB, TN; **USAFA**: Air Force Academy, Colorado Springs, CO; **ARL**: Army Research Laboratory

[2] CMS-Martin Stickley; CNR-Charbel N. Raffoul; GTO-Gerald T. O'Connor; JAH-Jay A. Howland; JJS-Jerry J. Sellers; PJO-Peter J. Ouzts; RSF-Robert S. Fredell; TL-Tim Lawrence

## EOARD Technical Personnel

US Address:
EOARD PSC 802 BOX 14
FPO AE 09499-0200
COMMERCIAL phone/fax: (+44) (20) 7514-4950/4960

UK Address:
223/231 Old Marylebone Road
London NW1 5TH UK
DSN: 235-4950/4960

| **Name** | **Functional Area** | **Phone** 7514-xxxx | **E-mail name** first.last@london.af.mil |
|---|---|---|---|
| Colonel Gerald T. O'Connor | Commander | 4376 | Gerald.oconnor |
| Lt Col Robert S. Fredell | Technical Director | 4505 | Rob.fredell |
| Lt Col David Burns | Sensors | | David.burns |
| Lt Col (sel) Jerry J. Sellers | Astronautics | 4318 | Jerry.sellers |
| Major Timothy J. Lawrence | Space Technology | 4285 | Tim.lawrence |
| Dr. Chris Reuter | Information Technology and C4I | 4474 | Chris.reuter |
| Dr. Charbel N. Raffoul | Aeronautical Sciences | 4299 | Charbel.raffoul |
| Dr. Peter J. Ouzts | NASA European Liaison | 4951 | Peter.ouzts |
| Dr. C. Martin Stickley | Lasers, Optics, and Materials | 4354 | Martin.stickley |
| Dr. Roy Phillips | Policy and Strategy | 4953 | Roy.phillips |
| Mr. Jay A. Howland | Physics & Ballistic Missile Defense | 4437 | Jay.howland |

## *Joint Points of Contact*

EOARD shares its London office, the Edison House, with other agencies from the US Army, Navy, and Air Force. For information about the functions and activities of these agencies contact those listed below. Telephone prefixes are DSN 235- or commercial +44-20-7514-xxxx.

| *Agency* | *Points of Contact* | *Phone Extension* | *e-mail* |
|---|---|---|---|
| **US Army Research and Development Standardization Group (USARDSG)** | vacant (Commander) | 4906 | |
| | Lt Col Tom McWhorter (Standardization Division Chief) | 4935 | **tmcwhorter@army.ehis.navy.mil** |
| **European Research Office (ERO), Army** | Dr. John Zavada, Director | 4907 | **jzavada@army.ehis.navy.mil** |
| **Office of Naval Research, International Field Office (ONRIFO), Europe** | CAPT Dennis Ryan, Commander | 4417 | **dryan@onreur.navy.mil** |
| | Dr. Michael Pestorius, Technical Director | 4508 | **mpestorius@onreur.navy.mil** |
| **Research and Development Liaison Office (RDLL), Air Force** | Col (sel) Mike Krimmer, Director | 4956 | Mike.krimmer@london.af.mil |
| | Mr. Craig Grand Pre, Deputy | 4668 | Craig.grandpre@london.af.mil |

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